RAPPORT: TECHNIQUE D'OPTIMISATION DANS LE DOMAINE DU GÉNIE CIVIL.

Optimization of logistic in construction

Construction logistics planning (CLP)

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INTRODUCTION:

Road construction projects represent a large part of the civil engineering work. Therefore logistics optimization is a consequential asset to take in consideration as an engineer or as a project manager.

Logistics optimization comes from effective planning and precise inputs, from the flow of information to the flow of material. A successful delivery of road requires a well-executed material delivery, material management and material handling.

Many researchers have redirected their work and efforts into this field, coming up with many examples of optimization techniques such as minimizing the cutting waste of steel bars used in construction projects; the practical application of this model helped in major cost savings, proposed by Salem and al in 2007 and Hazir's testified interest (2015) in the optimization models pertaining to all kinds of problems and issues in project management.

PROBLEMATIC:

In today ought climate, in order to prosper as a construction company or as manager a project to be pinpointed, brief and efficient. The lean philosophy aims to make a company fit, reducing costs while optimizing and improving performance, whence the importance to rely on logistics optimization that can be applied to small scale problems (like better organization of a single work station or storage area) or to the whole project management. In this context, we can only value optimization techniques and methods. Thus, this work is going to present the construction logistics planning (CLP)

- I chose this subject in regards of the importance road construction holds all over the world especially in the developing countries, it is considered to be one of the most significant projects a country could manage, and a project of this kind well-executed is a step further for a developed country. As important as those projects are it has become more fundamental to execute them with utmost care as to optimize the logistics and minimize the waste to lighten the cost.

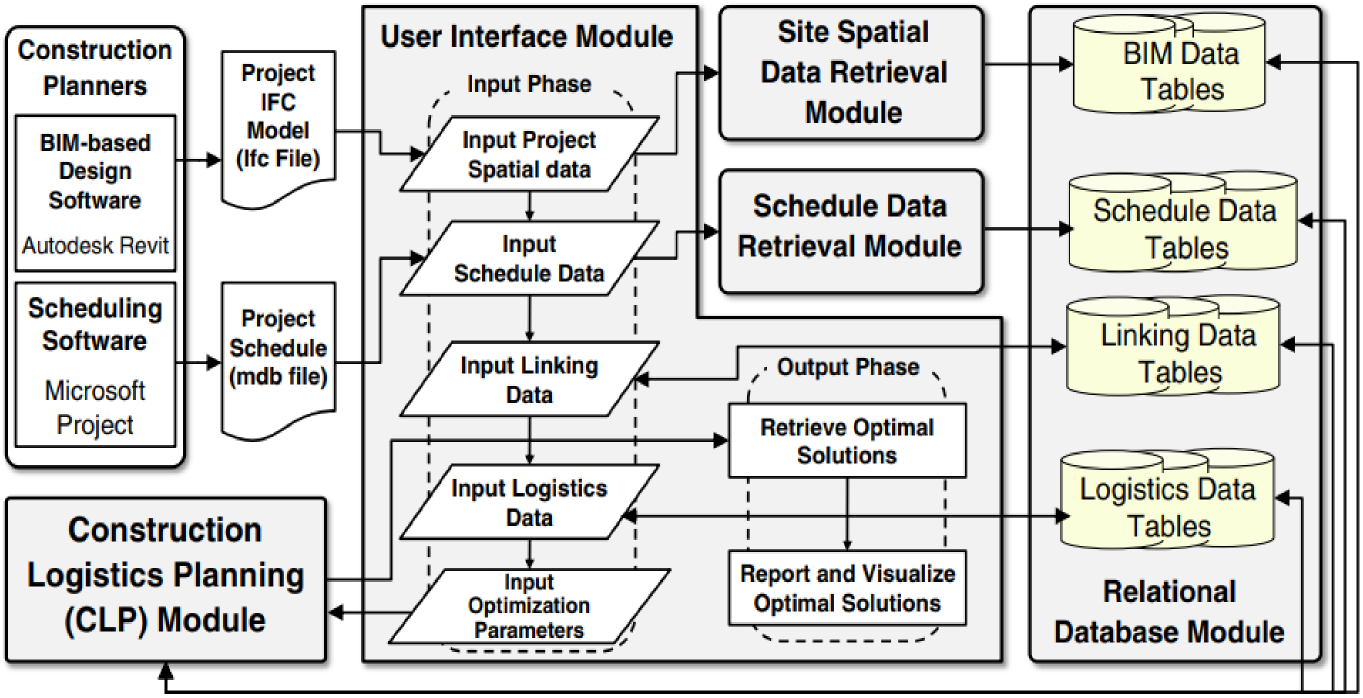
OPTIMIZATION TECHNIC:

Construction logistics planning (CLP) module is designed to generate optimal decisions of material supply and site logistics to minimize total logistics costs and schedule criticality. This module utilizes novel algorithms that are necessary to analyze construction logistics, such as assigning site spaces (indoor and outdoor) to material storage areas and modeling the impact of increasing site space availability on the criticality of the construction schedule.

The objective of the construction logistics planning (CLP) module is to integrate and optimize material supply and site layout decisions in order to minimize project total logistics cost and schedule criticality.

The CLP module requires planners to represent the project timeline as successive stages that represent major changes in space demand and material supply of construction activities. The CLP module classifies site space into interior building spaces (i.e. rooms) and exterior site level space that is represented as discrete grid locations.

Also interior storage reduces material supply costs, but increases project schedule criticality because of shifting interior construction activities.

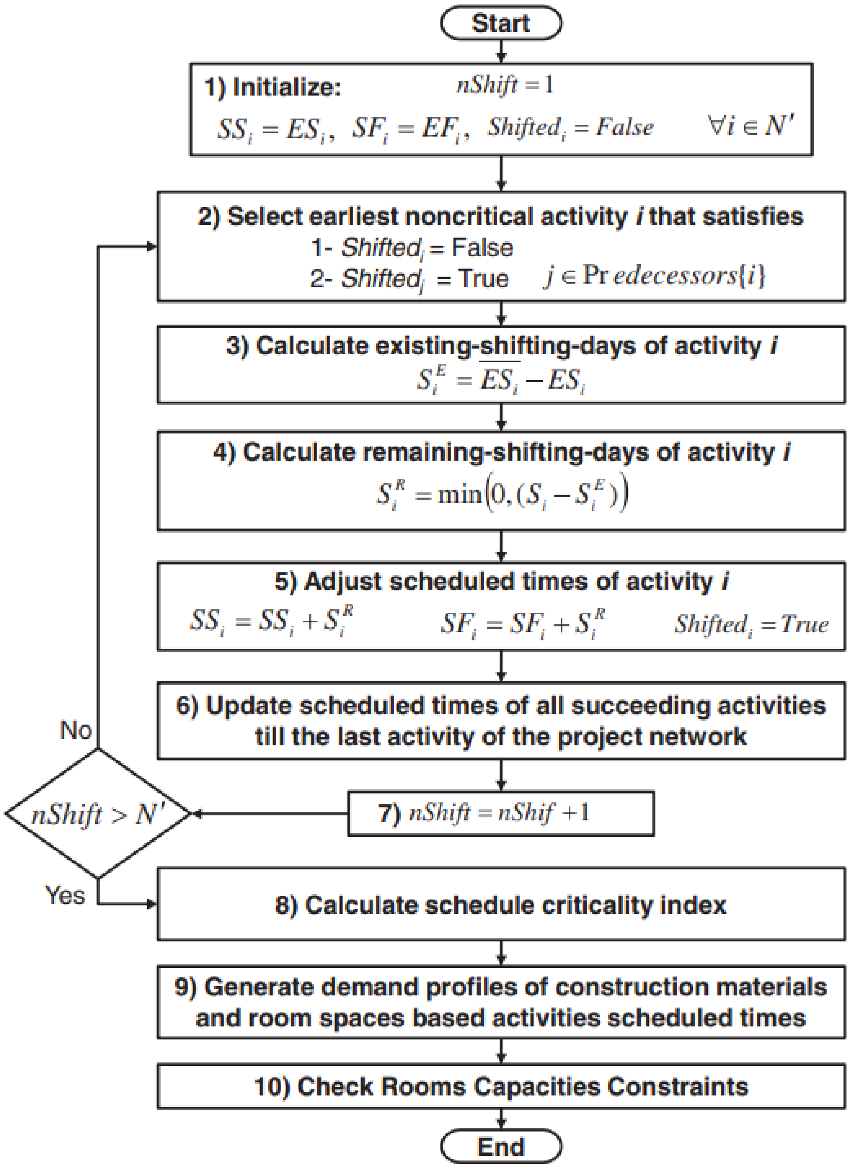


Construction Planners
BIM-based Design Software
Autodesk Revit
Scheduling Software
Microsoft Project
Project IFC Model (Ifc File)
Project Schedule (mdb file)
User Interface Module
Input Phase
Input Project Spatial data
Input Schedule Data
Input Linking Data
Input Logistics Data
Input Optimization Parameters
Output Phase
Retrieve Optimal Solutions
Report and Visualize Optimal Solutions
Site Spatial Data Retrieval Module
Schedule Data Retrieval Module
BIM Data Tables
Schedule Data Tables
Linking Data Tables
Logistics Data Tables
Relational Database Module
Construction Logistics Planning (CLP) Module

Four categories of decision variables are put into consideration:

- **Noncritical activities scheduling decision variables** are modeled as the minimum shifting days (S_i) of noncritical activities that can range from 0 day to the total float (TF_i) of each noncritical activity i.

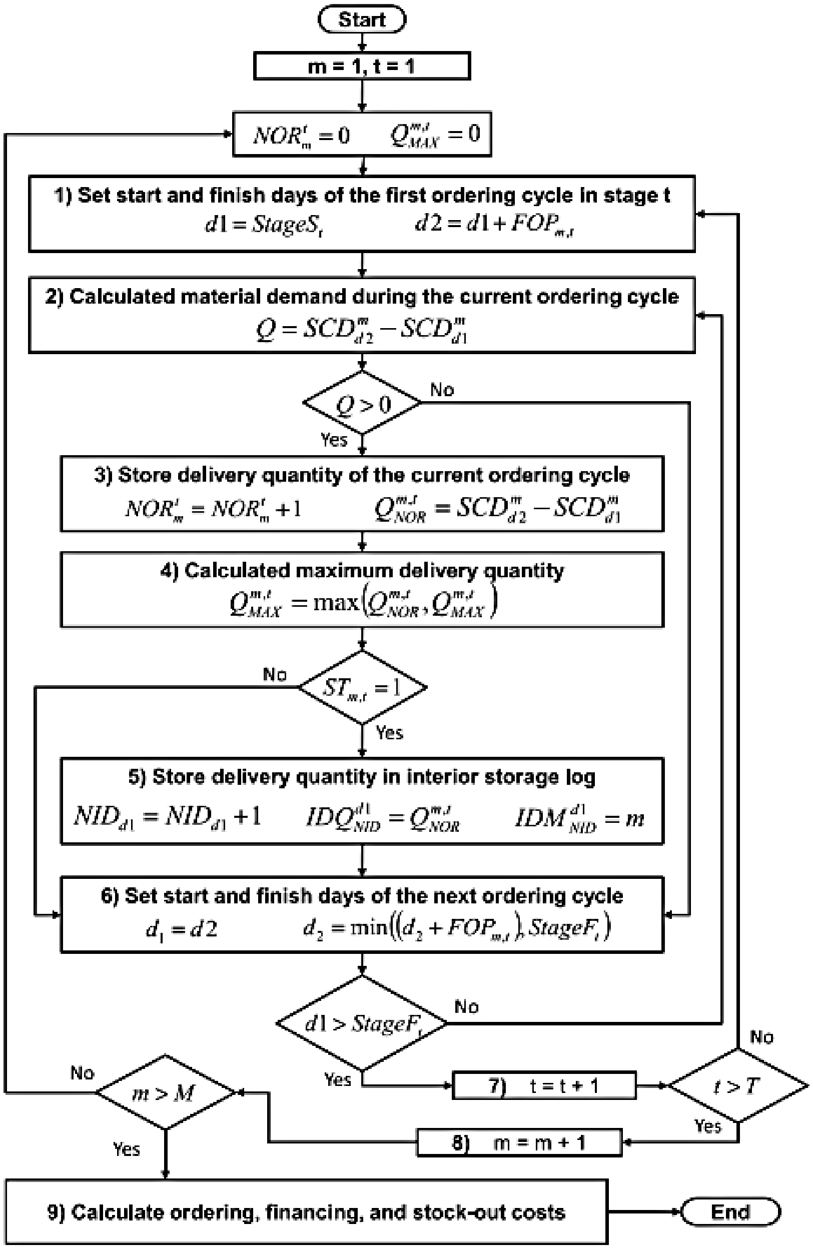
These decision variables are used to identify the optimal shifting of noncritical activities beyond their early times to generate more interior space for material storage while considering imposed interior space constraints, which include: room capacities, creation times of rooms, and permissible periods of interior material storage.


Start
1) Initialize: $nShift = 1$
$SS_i = ES_i,\ SF_i = EF_i,\ Shifted_i = False \quad \forall i \in N'$
2) Select earliest noncritical activity *i* that satisfies
1- $Shifted_i$ = False
2- $Shifted_j$ = True $j \in Predecessors\{i\}$
3) Calculate existing-shifting-days of activity *i*
$S_i^E = \overline{ES_i} - ES_i$
4) Calculate remaining-shifting-days of activity *i*
$S_i^R = \min(0, (S_i - S_i^E))$
5) Adjust scheduled times of activity *i*
$SS_i = SS_i + S_i^R$ $SF_i = SF_i + S_i^R$ $Shifted_i = True$
6) Update scheduled times of all succeeding activities till the last activity of the project network
7) $nShift = nShif + 1$
$nShift > N'$
No
Yes
8) Calculate schedule criticality index
9) Generate demand profiles of construction materials and room spaces based activities scheduled times
10) Check Rooms Capacities Constraints
End

- **Material supply decisions** include the Fixed-Ordering-Period for every material m in each construction stage t ($FOP_{m,t}$), which define the fixed time periods between material deliveries with variable quantities to satisfy construction schedule needs.

The possible value of the Fixed-Ordering-Period can range from 1 day to a maximum number of days that are specified by the planner.

A Fixed-Ordering-Period of one day represents a Just-in-Time (JIT) supply of materials, where material demand is satisfied on a daily basis and onsite material inventory is eliminated.


Start
m = 1, t = 1
$NOR_m^t = 0$ $Q_{MAX}^{m,t} = 0$
1) Set start and finish days of the first ordering cycle in stage t
$d1 = StageS_t$ $d2 = d1 + FOP_{m,t}$
2) Calculated material demand during the current ordering cycle
$Q = SCD_{d2}^m - SCD_{d1}^m$
$Q > 0$
No
Yes
3) Store delivery quantity of the current ordering cycle
$NOR_m^t = NOR_m^t + 1$ $Q_{NOR}^{m,t} = SCD_{d2}^m - SCD_{d1}^m$
4) Calculated maximum delivery quantity
$Q_{MAX}^{m,t} = \max(Q_{NOR}^{m,t}, Q_{MAX}^{m,t})$
No
$ST_{m,t} = 1$
Yes
5) Store delivery quantity in interior storage log
$NID_{d1} = NID_{d1} + 1$ $IDQ_{NID}^{d1} = Q_{NOR}^{m,t}$ $IDM_{NID}^{d1} = m$
6) Set start and finish days of the next ordering cycle
$d_1 = d2$ $d_2 = \min((d_2 + FOP_{m,t}), StageF_t)$
$d1 > StageF_t$
No
Yes
7) t = t + 1
No
$t > T$
Yes
No
$m > M$
Yes
8) m = m + 1
9) Calculate ordering, financing, and stock-out costs
End

- **Temporary facilities layout** is defined considering two decision variables for each temporary facility f in every stage t: site grid location ($L_{f,t}$) and orientation ($\theta_{f,t}$).

Optimal location and orientation decision variables of temporary facilities are generated by the CLP module while considering all safety and/or operational constraints that are represented using four types of layout geometric constraints: **boundary, overlap, distance, and zone constraints.**

First, the cost of material handling between exterior storage areas and demand activity locations is calculated considering the location of storage area (one of material storage plan decisions), location of the demand activity, demand quantity, and characteristics of the handling crew (i.e. handling capacity, speed, and hourly cost). The CLP module takes into account both the horizontal and vertical handling distances of material from the storage area to the location of demand activity.

Second, the time of site personnel and equipment traveling between site facilities is quantified in monetary values considering the locations of temporary facilities, speed of traveling resources and their hourly cost.

Third, the cost of reorganizing site layout between project stages is calculated to reflect changes in the locations or orientations of temporary facilities and exterior material storage areas. It should be noted that optimal layout decisions can result in reorganizing facilities locations between stages if it leads to savings in travel and handling costs.

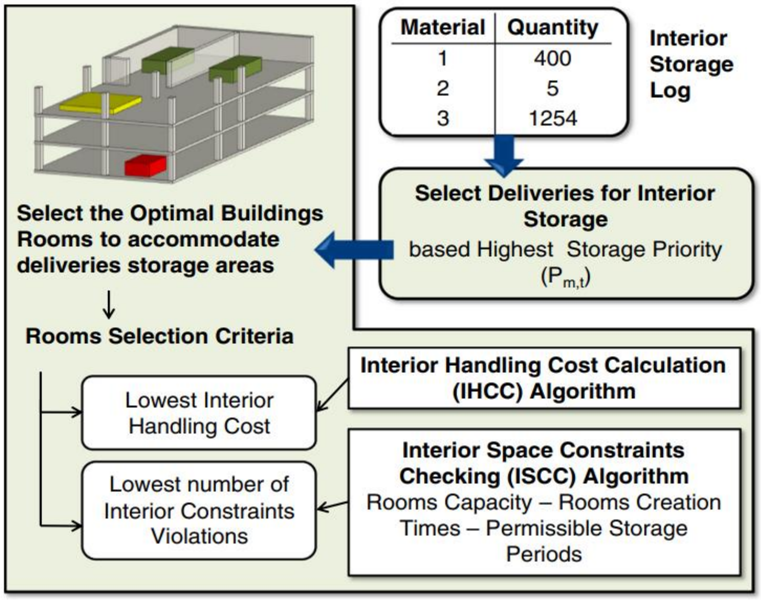
- **Material storage plan** decisions are used by the CLP module to generate material interior and exterior storage plans, which are represented by four decision variables for every material m in each construction stage t: material storage type (ST_{mt}), storage priority (P_{mt}), exterior grid location (L_{mt}), and orientation (θ_{mt}).

Material storage type can be either interior or exterior. If interior storage is selected for a material, a storage priority decision variable is considered in assigning interior building spaces to material deliveries. The layout of exterior storage area will be defined considering the values of its grid location and orientation, similar to the layout decisions of temporary facilities.

Optimal building rooms are selected to host the storage area of the material delivery in a way that achieves the following criteria:

1. The location of the room(s) centroid provides the lowest cost of handling the material to demanding activities, which is calculated using a sub-algorithm called Interior Handling Cost Calculation (IHCC) algorithm;

2. Storing the material delivery in the room will result in lowest number of violations to interior constraints (room capacities, room creation times, and permissible storage periods) that are calculated using an Interior Space Constraints Checking (ISCC) algorithm. Third, the previous two steps are repeated for all remaining material deliveries in day d.



Material	Quantity
1	400
2	5
3	1254

Interior Storage Log
Select Deliveries for Interior Storage
based Highest Storage Priority ($P_{m,t}$)
Select the Optimal Buildings Rooms to accommodate deliveries storage areas
Rooms Selection Criteria
Lowest Interior Handling Cost
Lowest number of Interior Constraints Violations
Interior Handling Cost Calculation (IHCC) Algorithm
Interior Space Constraints Checking (ISCC) Algorithm
Rooms Capacity – Rooms Creation Times – Permissible Storage Periods

ADDED VALUE:

Many technological, operational, and environmental problems affect the cost of a project, as well as the time and efficiency of execution. Traditionally, each contractor has his own supply chain that he manages, when working on a larger project with several contractors. In the case of a larger project involving a number of contractors, incompatibility of logistics concepts and lack of co-ordination results in serious disturbances in material and information flows.

Optimization in logistics comes in to define an efficient transfer of goods from the source of supply to the points of consumption in a cost-effective way while achieving acceptable level of customer satisfaction. In this industry, logistics management implies the coordination between material suppliers and contractors to integrate and optimize the supply and site operational decisions.

Many construction companies have adopted logistics management, and statistics show that 10% to 50% cost savings can be realized with efficient logistics management practices.

Furthermore, when implemented, proper logistics management can benefit clients (faster project implementation, improved projects, lower overall cost, reduced impact on the environment, waste minimization…) and contractors (improved project certainty, reduced over-ordering of materials, improved site efficiency, faster project implementation, reduced risk of accidents, lower overall cost)

The performance of the proposed system CLP was proven to be a reliable solution to the construction industry and is largely used in many countries such as the United States of America by the institute of business and management.

Good logistical planning facilitates overall productivity and flexibility, reduces clutter, and increases organization, all of which have major health and safety benefits.

ANALYSIS:

1. One possible reason for the limited implementation of logistics management in construction in Morocco is the industry's fragmentation and the need to incorporate and compile a vast volume of material logistics data and most importantly to keep track of the information on the input. Nevertheless the financial and time advantage this optimization technique brings cannot be denied, and as a developing country, Morocco has a consequential amount of road and infrastructure construction projects ahead of it. To opt for the construction logistic planning module would be a great strategic move that would ensure a better future for our economics.

2. As for the most suitable entity to secure an accurate implementation of the module would be a design office with engineering consultants for an obvious reason. As said on the beginning of this paragraph, the biggest limitation concerning construction optimization is the organization of the data input, besides designs office are shaped especially to handle these kinds of obstacles, furthermore similar works in foreign countries (such as the USA) were executed by engineering consultants which only reinforce this statement.

3. Concerning the likeability of this method to be even more developed, there have been multiple studies held over an automated multi-objective construction logistics optimization system named AMCLOS that is based on the CLP module amongst other algorithms which reinforces the results with more precision and accuracy. The studies that have been held on 2014 showed how well the program worked on hypothetical example, and further studies were to be held in order to expand AMCLOS efficiency.

CONCLUSION:

In brief, construction is the pillar of the development of a country. Road construction, infrastructure development and building innovation are the way for progress. Therefore, the importance of logistic imposes itself.

This work enhances the advantages of the **Construction logistics planning (clp)** optimization module that is based on the lean philosophy: minimum cost for maximum performance. The anterior uses of this method show its efficiency; up to 50% logistic cost savings can be achieved.

Finally, optimization in construction logistic is a large field and knows many researches taking place to this day in order to have the best optimization algorithm possible along with an automated solution that would make the data input much more fluid.

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